Value system simulation models

The REA ontology as a conceptual basis for simulation models

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Abstract. This paper presents a framework for the integration of supply chain, operational and financial simulation models, which should allow assessing the impact of supply chain and operational changes on an enterprise's financial performance. The REA ontology provides a shared conceptual ground for these three model types, as a foundational theory for building and integrating supply chain, value chain (i.e., financial) and business process (i.e., operational) simulation models. We show that the REA axioms help to define conceptually sound supply chain, value chain and business process simulation models and the integration points between them. It is further shown how these three types of simulation models are integrated into one value system model for discrete event simulation, making use of the ExSpecT simulation tool. With this ontology-based framework, simulation model builders should be able to scope their models better and define integration point with other models, which is expected to promote the (re)use of simulation models for different purposes (e.g., simulating logistic, operations and financial performance).

Keywords: supply chain; value chain; business process; REA ontology

1 Introduction

Church and Smith [1] advocate and demonstrate the use of simulation models for managerial decisions. Where most current approaches limit themselves to the simulation of logistical processes, considering only operational parameters such as production cost, services time, product quality and process flexibility [2], Church and Smith stress that business performance is mainly evaluated in terms of financial parameters (e.g., profit, net present value). Consequently, not only operational parameters such as operational cost but also financial parameters such as cost of capital should be taken into account when building simulation models for evaluating the future performance of alternative business process and supply chain designs. Bassett and Gardner [3] demonstrate the benefits of integrating financial parameters in supply chain simulation models.

In practice, businesses form a small part of a much larger economic and business environment. As a result, conceptual models for the purpose of simulating business processes and supply chains cannot be considered standalone artifacts. Porter and

adfa, p. 1, 2011.

Millar [4] provide a 3-layer framework that integrates business process models with supply chain models. The smallest elements of their framework are business activities. These business activities and processes construct a business' value chain, which transforms money into raw materials, raw materials into products and products into money that can be spent acquiring new raw materials. Where the bottom-layer of the framework is composed of business processes and activities and the middle-layer consists of value chains, the top-layer of Porter and Millar's framework is the value system, which is a supply chain model in which the supply chain partners' value chains and business processes are integrated.

Although Porter and Millar [4] propose this 3-layered conceptual framework, they only use it to address a business' challenges in a changing business environment regardless of its potential to integrate simulation models for managerial decisions. That is why this paper proposes a framework to create and integrate supply chain, value chain, and business process simulation models. The framework uses the REA ontology, which has been described at the supply chain [5], value chain [6, 7] and business process [8, 9] levels, to integrate these levels by identifying the invariant conditions that apply to all of these three levels.

The following section builds an example simulation model that integrates the supply chain, value chain levels, and business process levels. Conclusions and directions for future research are discusses in the last section.

2 Building an Example Value System Model

The Executable Specification Tool (ExSpecT) [10] was selected for the specification of the discrete-event simulation models in this paper, because of its full-graphic user-interface and sound formal basis in Petri-net theory. The tool was specifically developed to monitor and analyze the service level provided by specific business process lay-outs by tracking workloads, money, goods and information flows. [11] The Expect tool incorporates features of colored, timed and hierarchical Petri-nets. These different types of Petri-nets add specific features to conventional Petri-nets. Colored Petri-nets allow us to add data to tokens and specify pre- and post-conditions for transitions. Timed Petri-nets allow us to incorporate temporal aspects (e.g. delay, duration) in our simulation models. Hierarchical Petri-nets allow us to decompose and integrate Petri-nets.

2.1 Supply Chain Model

The supply chain model provides the top layer of our model hierarchy, and uses the REA ontology as it is specified in ISO's Open-edi Business Transaction Ontology (OeBTO) [5]. This top-layer model shows organizations, which are a sub-type of REA's economic agent construct, and are defined as 'a unique framework of authority within which a person or persons act, or are designated to act, towards some purpose'. [5] Figure 1 shows a simple 3-stage supply chain model containing a central enterprise and its supplier and customer. The supplier, enterprise and customer systems represent the organizations that construct this supply chain. The product channels represent the product flows between these trading partners and the money channels represent the money flows between them. The offer, invoice and order channels then represent information flows that help coordinate these resource (i.e., product and money) flows. Each of the organizations in this supply chain model has an internal value chain, which is modeled as a subnet.

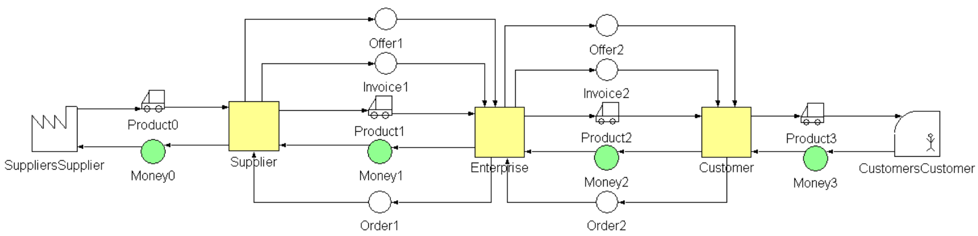

Fig. 1. An example supply chain model

2.2 Value Chain Model

The value chain model provides the middle layer of our model hierarchy, and uses the REA ontology as it is specified in [6]. This middle layer shows the entrepreneur script, which describes how trading partners engage in value-added exchanges. This entrepreneur script contains three major parts (i.e., acquisition, revenue and conversion cycle) and an auxiliary part (i.e., financing cycle). As this entrepreneurial script model provides the interface between supply chain and business process models, it allows us to assess the financial impact of operational decision in a supply chain or an enterprise's business processes (e.g. How does an alternative organization of the supply chain affect the financial performance of individual supply chain partners?, How does an alternative organization of an enterprise's business process affect the financial performance of that enterprise and its supply chain partners?).

Figure 2 shows two inflow (i.e., purchase and get paid) and two outflow events (i.e., sale and pay). Representing the acquisition cycle, the purchase and pay processors are paired in duality through the duality acquisition monitor, which monitors the balance between the purchase inflows and the pay outflows. A second monitor is used to represent the revenue cycle, which connects the sale outflow to the get paid inflow. The conversion cycle is then represented by an ExSpecT system that requires material inflows and generates product outflows, along with various information inputs and outputs (i.e., offers, order and invoices) that assure communication with other trading partners and coordinate business processes. These information in- and outputs (which are modeled vertically) are the integration points with the supply chains layer, together with the resource inputs and outputs (which are modeled horizontally). For example, Product1 can also be found in fig. 1. Finally, the financing cycle is also represented by an ExSpect system that generates money outflows for the pay process from money inflows from the get paid process for invoices that came in.

As REA explicitly abstracts from overhead costs, support activities are not modeled separately. At the business process level, support activities can be recognized by the fact that they consume resources that have been acquired, but those resources do not directly contribute to the production of resources that are sold (e.g. acquisition of computer equipment that contributes to the information processing in the conversion or financing cycle, but does not lead to artifacts the enterprise's customers are interested in). On the other hand, primary activities can be recognized by the fact that the business processes they are part of connect the acquisition cycle with the revenue cycle through a chain of resource manipulations.

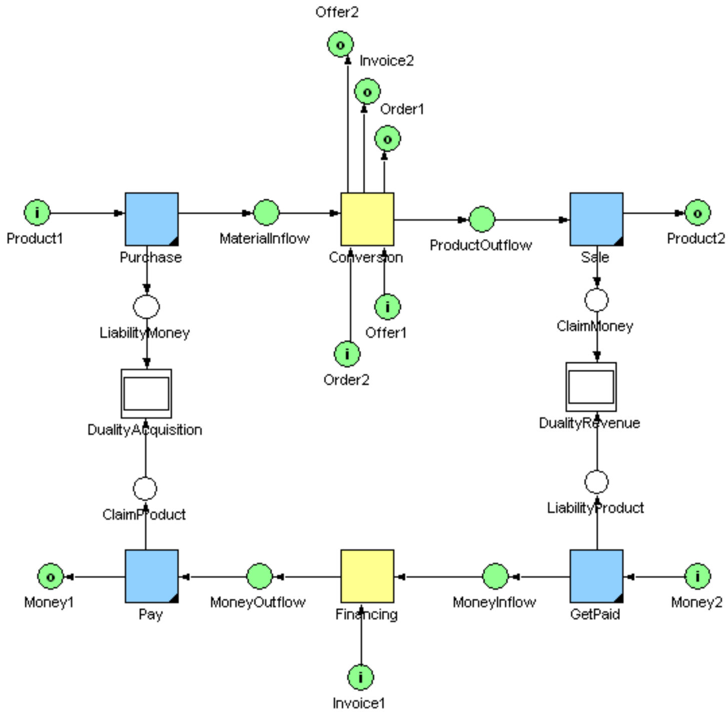

Fig. 2. An example value chain model.

2.3 Business Process Model

The business process model provides the bottom layer of our model hierarchy, and used the REA ontology as applied in [8, 9]. This layer shows business processes as they are usually represented (i.e., with a particular purpose and as part of a larger organization). Figure 3 shows an example business process model, that is part of the conversion system in figure 2. It generates and sends out offers and augments the stock of raw materials when materials are received (i.e., increment event) by a clerk. The STOCKRAW monitor registers the type, amount and value of raw materials in stock. When an offer comes in, raw materials are consumed (i.e., decrement event) and final products are produced (i.e., increment event). A worker controls this whole process. A work in process (WIP) monitor registers the type, amount and value of unfinished products. When final products are produced, they are stocked and the

STOCKFINAL monitor registers their type, amount and value. When they are dispatched (i.e., decrement event) by a dispatcher an invoice is created. The resource and information in- and output pins relate to channels in the value chain model (e.g. OFFER2 can also be found in fig. 2). Again, resource flows are modeled horizontally, information flows vertically.

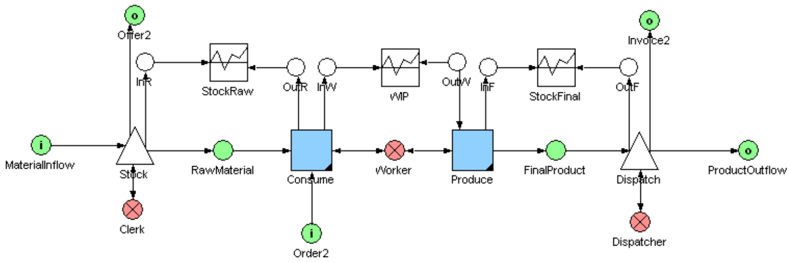

Fig. 3. Example business process model

Conclusions

In this paper we demonstrated that the REA ontology can be used at three different business simulation modeling levels (i.e., supply chain, value chain and business process), developing a framework for the integration of these three kinds of simulation models. Where conventional business process, workflow and supply chain simulations limit their scope to operational parameters (e.g., service time, production cost), the REA ontology's accounting basis allows for the incorporation of a whole range of financial parameters (e.g., added value, total profit, debt). Using the ExSpecT simulation tool as an example modeling technology, we demonstrated both the simplicity and power of the presented modeling framework.

The simplicity and integration power of the framework can be observed in the example models that integrate distinct and clearly scoped models into a complete value system model by following the conceptual modeling rules incorporated in the REA ontology.

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